PEA ASSESSMENT OF XLPE AND SEMICON COMPOUNDS FOR HVDC APPLICATION: MEASUREMENTS ON PLAQUE AND MINI-CABLES

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ABSTRACT

Different XLPE and semicon compounds were analyzed in terms of their suitability for application in HVDC cables. The results from space charge measurements on two types of cross-linked polyethylene (XLPE) materials are presented in this work. Measurements were performed at two temperature profiles and at two poling fields. The performance of test samples were analyzed in terms of the poling field, the temperature, the cumulative space charge profile, the Field Enhancement Factor (FEF) and in terms of the time constants for the accumulation and depletion of space charge. Test samples were subsequently ranked for HVDC cable application.

KEYWORDS

HVDC, power cables, XLPE, mini-cable, space charge

INTRODUCTION

There are major technical difficulties to overcome when performing space charge measurements on full scale HVDC power cables. These problems together with time and cost constraints are overcome by performing space charge measurements on plaques, mini-cables and MV-sized cables [1-4].

In this paper the results from Pulsed ElectroAcoustic (PEA) space charge measurements on two types of cross-linked polyethylene (XLPE) materials are presented. Insulation type 1 (INS1) consists of an XLPE base material with an organic charge trapping agent and insulation type 2 (INS2) consists of an XLPE base material with the addition of a low level of inorganic additive.

The mini-cable can be viewed as a scaled down test model of a DC power cable. A typical mini-cable used for space charge measurements consists of an inner conductor, an inner semi-conductive layer, the insulation, an outer semi-conductive layer and a conductive screen.

Mini-cable samples comprising inner and outer semiconductive screens, and the insulation layer, were manufactured using a triple head extruder. This production process is similar to that used on full size power cables, resulting in chemically bonded interfaces in the mini-cables. Furthermore, the scaled down geometry facilitates testing at high electrical field stresses.

The two insulation types and their respective space charge behaviors were investigated through PEA measurements on plaques and on mini-cables. Measurements were performed at two temperature profiles and for two electrical poling fields.

In the case of the mini-cables, the first temperature profile was performed at room temperature and no temperature gradient was present. The second profile was at high temperature, achieved using an induced current heating technique. This resulted in a temperature of 65℃ at the inner conductor and 55℃ at the outer semiconductor layer; thus giving a temperature drop of 10℃ between the inner conductor and the outer semiconductive layer of the mini-cables. Furthermore, during testing of the plaque samples, isothermal test conditions were used. Tests were performed at room temperature and at an elevated temperature of 60℃.

TEST SAMPLES

PEA measurements were performed on plaques and on mini-cables. The diameter of the plaque samples tested were 0.12 m and the thickness of each sample was between 0.2 mm and 1 mm. Each plaque was produced using a pressure moulding technique. Each sample was thermally treated before PEA measurements were performed.

	Diameter (in)	Diameter (mm)
Conductor	0.064	1.63
Inner SC	0.104	2.64
Insulation	0.224	5.69
Outer SC	0.284	7.21

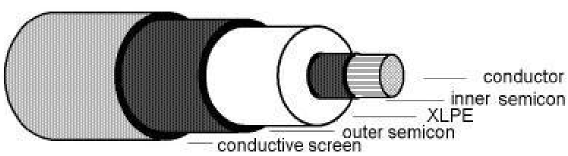

Figure 1. Mini-cable specifications

A schematic of a mini-cable showing the radial dimensions is given in Figure 1. The mini-cables are each 10 m in length. Each mini-cable is produced using a triple extrusion process where the semi-conductive layers are chemically bonded to the insulation through a cross linking process.

The extrusion process results in semicon-dielectric chemical bonds similar to the situation found in power cables. The mini-cables are also preconditioned before testing in order to reduce the concentration of manufacturing by-products present. This preconditioning involves thermally treating the cables for some days at 80℃ in an oven and has been successfully used in previous studies [2].